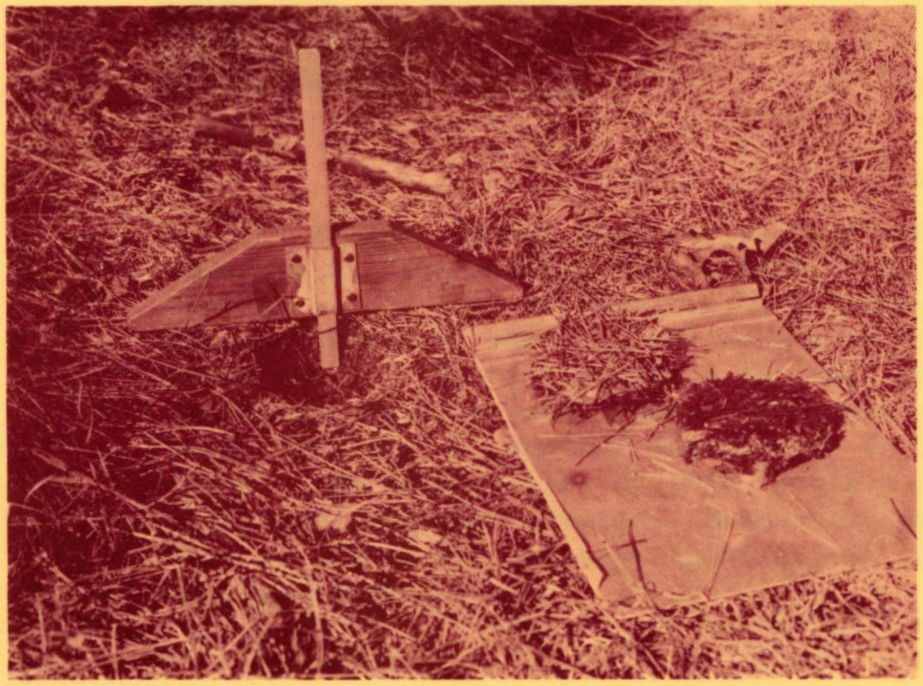
Litter-and-Duff Fuel in Shortleaf Pine Stands in Southeast Missouri

John S. Crosby



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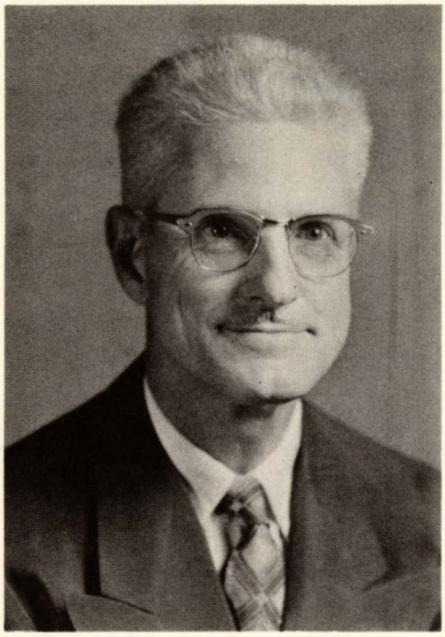

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Studies of the accumulation of litter and duff in Missouri Ozark shortleaf pine forests reveal that in general the layer of this material is thin but that its depth is related to basal area of the pine. Because litter dries fast, its weight alone probably gives a better measure of available forest fire fuel than the combined weight of litter and duff.

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by

John S. Crosby

It is well known that wildfires differ in intensity. Part of this difference in wildfire intensity can be attributed to variations in the amount of fuel available for burning (2)[1/]. Information on the amount of fuels would help in estimating fire intensity and behavior but such information is scarce.

Because litter and duff are the principal forest fire fuels on much of the Missouri Ozark forest land, a study of the weight and depth of litter and duff and the annual accumulation of litter under shortleaf pine stands in southeast Missouri has been made. The results of this study are reported here; subsequent reports will cover other kinds of fuels.

1/ Numbers in parentheses refer to Literature Cited, page 10.

FORTY-EIGHT STANDS WERE SAMPLED

Litter and duff were measured in 48 shortleaf pine stands located in four southeastern Missouri counties during the spring fire seasons of 1956 and 1958. The stands ranged from 19 to 76 years in age and from about 60 to 170 square feet in basal area per acre, including some scattered hardwoods. None of the stands had burned for at least 20 years.

Six of the stands were old-field plantations and the rest were natural stands. Most of these stands had been thinned as a result of timber sales in which pine posts and poles and pine and hardwood sawlogs were harvested. Additional release of pine had been made during timber stand improvement operations following thinning. In all the stands shortleaf pine accounted for 80 percent or more of the total basal area in trees 1 inch d.b.h. and larger.

Weight and depth of litter and duff were measured in all 48 stands, but measurement of litter accumulation was confined to 30 of the natural even-age stands. These 30 stands, 34 years old when collection began, included unthinned stands having about 135 square feet basal area in 1951 and stands thinned in 1951 to 50, 70, 90, or 110 square feet basal area. Three different methods of thinning were tried: selection (leaving the best trees with good distribution), thinning from above, and thinning from below; and three hardwood treatments were used: leaving all hardwoods, leaving only understory hardwoods, and leaving no hardwoods. By 1956 basal area had increased to about 60, 90, 108, and 126 square feet per acre in the thinned stands and to about 155 square feet in the unthinned stands.

Weight of litter and duff was estimated from composite samples made up of 64 sub-samples, taken randomly from half-acre areas in each stand. Preliminary tests showed that this sample size would give an estimate of the mean total weight of litter and duff per acre with an error of less than 5 percent.

Figure 1.—Gauge used to find depth of litter and duff. A sub-sample has been removed and is shown in the can at left.

Sub-samples were taken by pressing an inverted metal can, 3.8 inches in diameter, into the litter, cutting around the can, and then lifting out the enclosed organic material down to mineral soil. The sub-sample was then separated into two parts: litter, the loose upper part consisting of organic material only slightly altered and still easily identified; and duff, the more compacted and matted part of the same source material in various stages of decomposition, difficult or impossible to identify, and lying between the litter and the mineral soil[2/]. The two parts were composited separately for each stand and separate oven-dry weights were obtained for litter and duff. Branchwood larger than 1/2 inch in diameter was eliminated from the sample.

The combined depth of litter and duff was measured at each sub-sample spot with a gauge that permitted uniform pressure on the top of the litter (fig. 1).

Four bushel-basket traps per 1/2 acre were used to catch the litter fall (6). Collections were made seven times a year (Jan., April, Aug., Sept., Oct., Nov., and Dec.) for 5 years beginning in August 1954.

2/ The material called duff would conform in general to the F and H layers or the A_o layer (7). It is difficult to make a precise separation, but the objective was to separate the loose material from the more or less compacted parts lying closer to the soil which have different burning characteristics.

LITTER-AND-DUFF QUANTITIES ARE RELATED TO STAND BASAL AREA

WEIGHT OF LITTER AND DUFF

Quantities of litter and duff differed among stands but were related to shortleaf pine basal area. Weights of litter and duff in 48 individual stands ranged from 8.0 to 15.3 tons per acre (0.37 to 0.71 pounds per square foot) and averaged 11.3 tons per acre. Litter makes up about one-third the total weight of dead organic material and duff two-thirds. Multiple regression analysis of the relations between weight of litter and duff per acre and stand basal area, slope, aspect, ratio of pine basal area to total basal area, and stand age, showed that only stand basal area was significantly related to the weight of litter and duff (fig. 2).

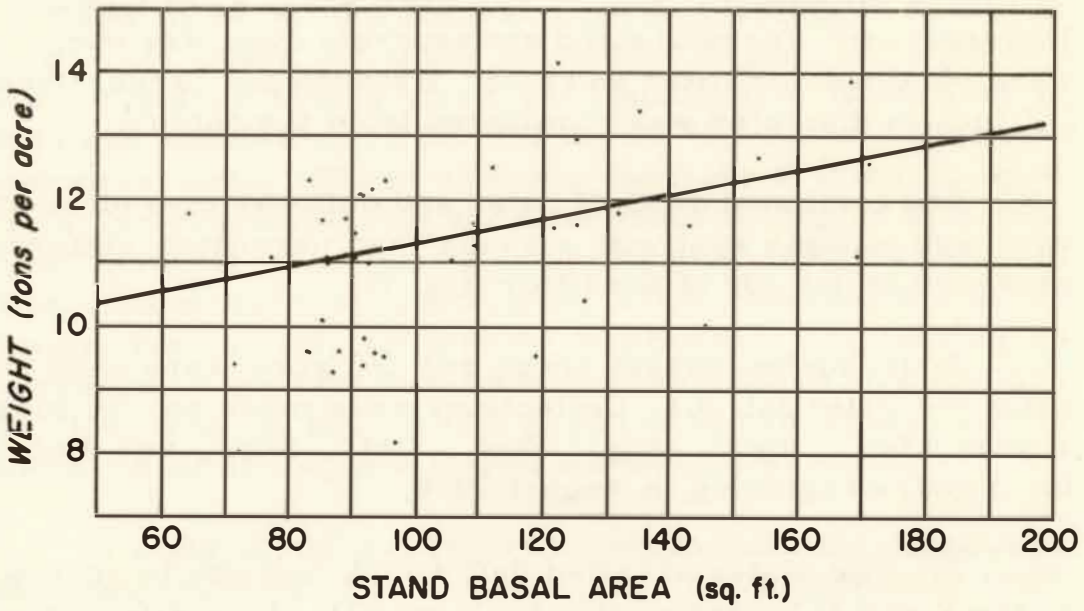

Figure 2.—Relation of shortleaf pine litter-and-duff weight to stand basal area.

ANNUAL ACCUMULATION OF NEW LITTER

The amount of annual litter accumulation was also related to stand basal area. A stand having 100 square feet basal area per acre will produce about 1.7 tons dry weight of litter per acre per year (fig. 3). The annual accumulation in stands ranged from 0.9 to 2.4 tons per acre per year, and amounts to about one-sixth of the weight of litter and duff on the ground.

No significant differences were found in litter accumulation because of thinning methods or hardwood treatments.

Litter fall varied by years. The maximum annual accumulation for any stand sampled was twice the minimum for that stand. Studies with other species and in other locations show that the maximum may be as much as three times the minimum (3), (4).

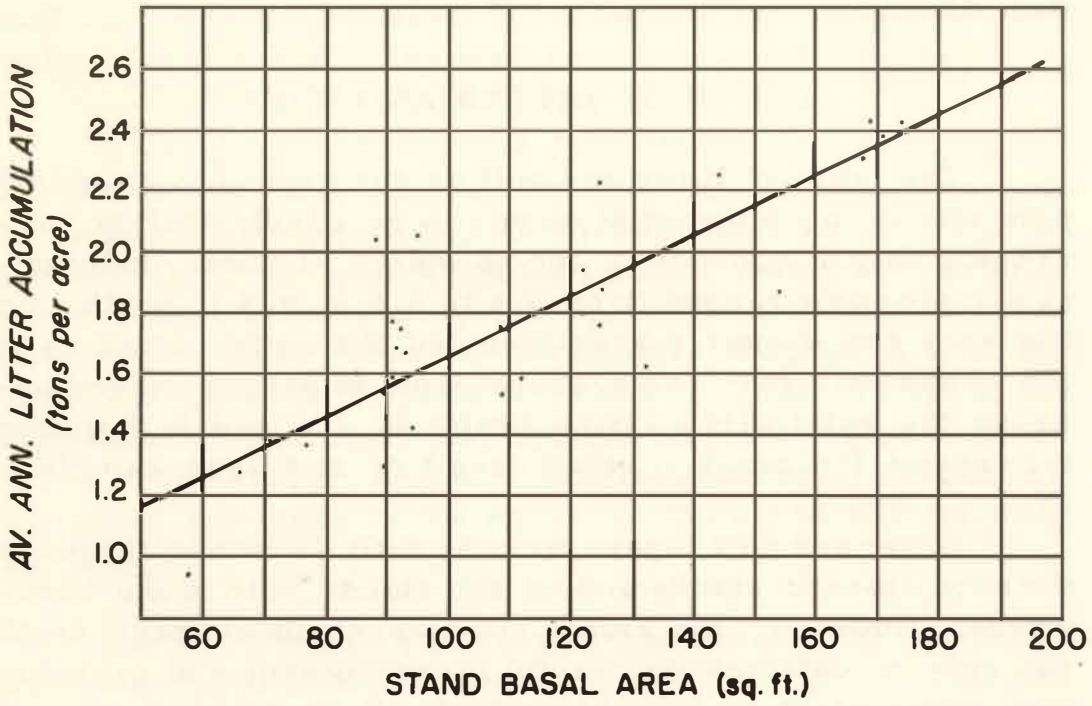

Figure 3.—Relation of average annual shortleaf pine litter accumulation to stand basal area.

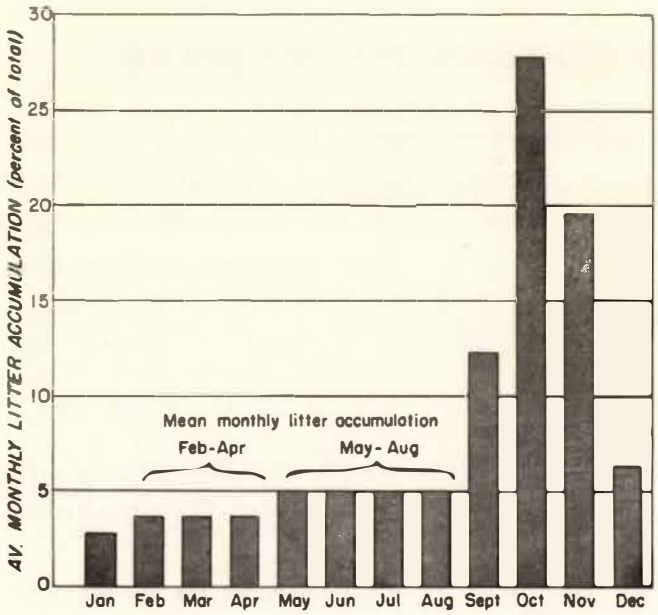

Figure 4.—Distribution of annual litter accumulation in shortleaf pine stands in southeast Missouri by months.

As in hardwood stands the heaviest litter fall occurred in the autumn. Although some new litter falls each month of the year, about 60 percent of the total amount accumulates in the months of September, October, and November (fig. 4).

DEPTH OF LITTER AND DUFF

The layer of litter and duff on the ground in shortleaf pine stands in southeast Missouri is relatively shallow, averaging only 1.6 inches in the 48 stands studied. Individual sample spots ranged from 0.4 to 6.0 inches in depth, but the very few deeper places included the rotten remains of old limbs or logs. The average depth in stands ranged between the relatively narrow limits of 1.2 and 2.0 inches throughout the range of stand densities and ages sampled.

Litter and duff layers were slightly deeper in the more densely stocked stands and in the stands with more hardwoods. However, the small differences in average depth can only be detected by careful measurement and probably are unimportant in evaluating fuel. It is more important that this layer of fuel is strikingly uniform in depth and that small differences in average depth of litter and duff may mean large differences in total weight of material per acre.

LITTER-AND-DUFF QUANTITIES CHANGE

New litter is continually being added to the forest floor while biological and chemical actions operate to reduce its weight. Because these two processes are probably seldom in balance, the total amount of forest floor material must be constantly changing.

Blow (1) found that in eastern Tennessee mixed oak litter weight reached a peak in December following leaf fall and decreased to a minimum in August. Seasonal differences were not measured in the present study, but it is logical to expect that a similar seasonal change is taking place in the Missouri stands because the climate and time of litter fall are similar to those in Tennessee.

Long-time changes may also be taking place but these are more difficult to define. Kittredge (4) concludes that "the amount of the forest floor in a given region and type increases with age for 30 to 80 years and thereafter varies with age, site, and density but often without systematic relation to any one of these factors."

It is impossible to tell from these data whether the amount of litter and duff has reached a maximum in any of the stands studied. Although the non-significant relation between stand age and weight would indicate that a balance was reached by 20 years, the age of forest floor in these stands is probably of more importance than the age of the trees. Because of frequent fires before 1935, the age of the undisturbed forest floor may not differ by more than 10 years in any of the stands, and this difference in age is too small to permit assessing differences in litter-and-duff quantity due to age.

Despite the fact that the average annual litter accumulation amounted to about one-sixth of the weight of litter and duff found on the ground, it cannot be assumed that 6 years' litter fall would accumulate to the amounts found in these stands, for losses in weight from leaching and decomposi-

tion begin almost immediately and continue for several years (5). Thus more than 6 years, and perhaps as many as 25 years, were required for the forest floor material in the sample shortleaf pine stands to attain the weights found in this study. Though the age at which the forest floor has maximum weight cannot be established, it is significant that for approximately the same age of forest floor, and for all stand ages studied, the weight of litter and duff was related to stand basal area rather than the age of the trees.

Site and climate may have an important influence upon the amount of litter and duff and the age at which some balance of gains and losses is reached. Differences in site quality among the 48 stands examined were very small and not considered in the analysis, but both site and climate vary over the range of shortleaf pine in the southeastern United States. So, the amounts and depths of litter and duff found in this study may be peculiar to the climate and sites found in this region.

FAST-DRYING LITTER IS AN IMPORTANT FUEL

In Missouri most forest fires in stands having a well-developed forest floor burn almost all the litter, but few fires burn all the duff. Moisture content of litter responds faster to changes in atmospheric humidity and is usually drier than the duff because it is more exposed and loosely arranged. Although the topmost needles and leaves on the ground dry to flammability first, the lag in drying of the whole litter layer is short. But the more compact and protected duff layer dries slowly and may maintain a moisture content of 30 percent or more for many days or weeks.

The amount of litter-and-duff fuel available for burning is governed to a large extent by the moisture content of the fuel. Thus in the early stages of drying, up to 3 to 5 tons per acre of pine-litter fuel may become flammable quickly, but it takes a much longer time to dry the duff fuel enough to burn readily. Moreover, in the more compact

duff, fires burn slowly and tend to go out. Some of the duff does not burn even during severe drought. Other things equal, the difference between the least and the greatest amounts of litter fuel found in the 48 stands would be almost enough to double the intensity of a fire if all would burn.

A SUMMING UP

Average depth and weight of litter and duff was measured in 48 shortleaf pine stands covering a range of stand ages, densities, and locations in southeast Missouri. Annual accumulation of new litter was studied on 30 of the stands that were even-aged and had been reduced to different basal areas by earlier thinnings.

The relations of stand basal area, ratio of pine basal area to total stand, basal area, aspect, slope and age of stand to the dry weight of litter and duff per acre were studied. Only stand basal area was found to be significantly related to the weight of litter and duff.

The litter fraction of the forest floor is about one-third the total dry weight of litter and duff. In early drying periods, litter weight alone may give a better approximation of available fuel than litter-and-duff weight together. Differences in litter quantities are enough to cause appreciable differences in fire intensity if the rate of spread of fires is constant.

Annual litter accumulation was related to stand basal area. Large differences in annual accumulation of litter occur in different years, but the heaviest litter fall always occurs in the autumn.

The average depth of litter and duff in all stands is relatively shallow and the differences in depth among stands are small.

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